TWR-64222

SPACE SHUTTLE

Solid Rocket Motor
Thiokol Corporation

Final Postflight Hardware Evaluation Report RSRM-29, STS-54

September 1993

Prepared for:

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
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September 20, 1993
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George C. Marshall Space Flight Center
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Attention Mr. V. K. Henson, SA51

Gentlemen:

Subject: Transmittal of Final Postflight Hardware Evaluation Report RSRM-29, STS-54, TWR-64222, DR 4-23, Type 2 Documentation

The subject document dated September 1993 has been prepared in accordance with DPD 400, Contract NAS8-38100, and copies are transmitted herewith in accordance with NASA/MSFC distribution requirements.

If you have any questions or comments concerning this transmittal, please direct them to the undersigned.

Very truly yours,

Robert M. Papasian
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Final Postflight Hardware Evaluation Report RSRM-29, STS-54

September 1993

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Case Design

Joints & Seals Design

Integration Design

Nozzle Design

Igniter / Instrumentation / Electrical Design

Thermal Insulation Design

Quality, Performance Evaluation

Systems Assurance

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List of Acronyms

Acronym	Definition
AO	Action Order
CCP	Carbon Cloth Phenolic
CEI	Contract End Item
CF/EPDM	Carbon Fiber/Ethylene–Propylene–Diene Monomer (Insulation)
CPT	Component Program Team
CSF	Compliance Safety Factory
DR	Discrepancy Report
GCP	Glass Cloth Phenolic
HDI	High Density Indication
IBR	Inner Boot Ring
ID	Inside Diameter
IFA	In-Flight Anomaly
KSC	Kennedy Space Center
LDI	Low Density Indication
LH	Left Hand
MDD	Material Decomposition Depth
N/A	Non–Applicable
NASA	National Aeronautics and Space Administration
NBR	Nitrile Butadiene Rubber
OD	Outside Diameter
PEEP	Postflight Engineering Evaluation Plan
PFAR	Postfire Anomaly Record
PFOR	Postfire Observation Record
RH	Right Hand
RTR	Real Time Radiology
RSRM	Redesigned Solid Rocket Motor

RTV	Room Temperature Vulcanized (Rubber)
S&A	Safe and Arm Device
SII	SRM Ignition Initiator
SPR	Significant Problem Report
TWA	Thiokol Wasatch Analysis
STS	Space Transportation System
TWR	Thiokol Wasatch Report
UUEC	Unexpected/Unintended Event or Condition

1.0 INTRODUCTION

This document is the final report for the Clearfield disassembly evaluation and a continuation of the KSC postflight assessment for the RSRM-29 flight set. All observed hardware conditions were documented on PFORs and are included in Appendices A, B, and C. Appendices D and E contain the measurements and safety factor data for the nozzle and insulation components. This report, along with the KSC Ten-Day Postflight Hardware Evaluation Report (TWR-64221), represents a summary of the RSRM-29, hardware evaluation. Disassembly evaluation photograph numbers are logged in TWA-1990.

The RSRM-29, flight set disassembly evaluations described in this document were performed at the RSRM Refurbishment Facility in Clearfield, Utah. The final factory joint demate occurred on September 9, 1993.

Detailed evaluations were performed in accordance with the Clearfield PEEP, TWR-50051, Revision A. All observations were compared against limits that are also defined in the PEEP. These limits outline the criteria for categorizing the observations as acceptable, reportable, or critical. Hardware conditions that were unexpected and/or determined to be reportable or critical were evaluated by the applicable CPT and tracked through the PFAR system.

Figure 1 shows the RSRM Case Configuration.

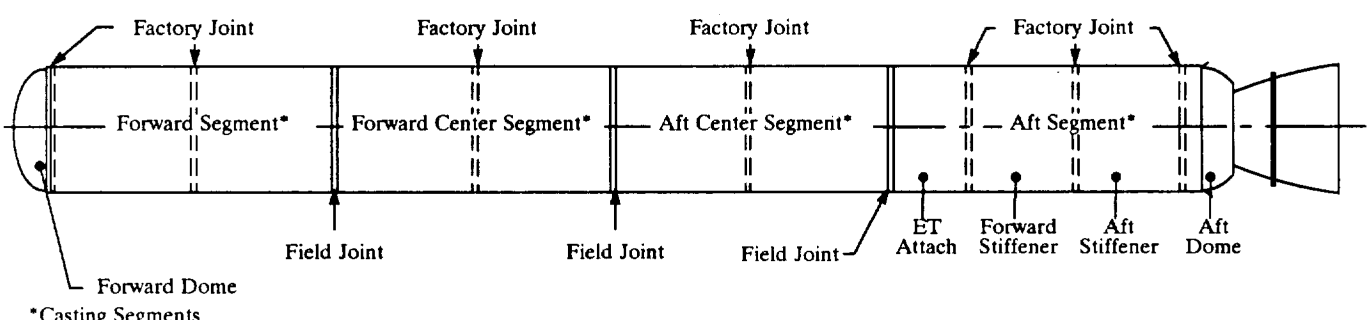

Figure 1. Case Configuration

2.0 REFERENCES

The following documents are referenced herein:

CPW1-3600A	Prime Equipment End Item Detail Specification, Part I of Two Parts; Performance, Design, and Verification Requirements, Space Shuttle Redesigned Solid Rocket Motor CPW1-3600 For Space Shuttle Solid Rocket Motor Project, Operational Flight Motors (RSRM-4 and subsequent)
TWA-1990	RSRM-29, STS-54, Clearfield Postflight Photo Log
TWR-50050	KSC Postflight Engineering Evaluation Plan (PEEP)
TWR-50051	Clearfield Postflight Engineering Evaluation Plan (PEEP)
TWR-64219	Postflight Hardware Special Issues, RSRM-29, STS-54, Clearfield
TWR-64221	KSC Ten-Day Postflight Hardware Evaluation Report, RSRM-29, STS-54
TWR-64223	RSRM Hardware Assessment at KSC (Presentation of RSRM-29 PFARs to RPRB)

3.0 EVALUATION SUMMARY

Table I provides a summary of all postflight-related Squawks/Preliminary PFARs, PFARs, IFAs, and SPRs for RSRM-29.

Table I. Summary of RSRM-29, Problems

	Squawks/Prelim. PFARs	PFARs	IFAs	SPRs
KSC	19	12	0	1
Clearfield	3	1	0	0
Total	**22**	**13**	**0**	**1**

A list of all RSRM-29 PFARs is included in Table II. This includes Squawks (written at KSC) and Preliminary PFARs (written at Clearfield) that were written and not elevated to PFARs. Information relating to postflight Squawks can be found in TWR-64221.

3.1 CEI Specification Compliance

Based on hardware evaluations at KSC and Clearfield, as defined in the respective PEEPs (TWR-50050, Revision C and TWR-50051, Revision A), all CEI (CPW1-3600A) motor performance requirements were met.

Table II. Problem Summary for RSRM-29

PFAR/SQUAWK/ PRELIM. PFAR NUMBER	TYPE	ELEVATED FROM	SPR NUMBER	IFA NUMBER	EVALUATION LOCATION	COMPONENT	SPAT/ RPRB DATE	DESCRIPTION
54-001	SQUAWK	N/A	N/A	N/A	KSC	CASE	01/15/93	UNBONDED PAINT ON RH CENTER FORWARD SEGMENT
54-012	SQUAWK	N/A	N/A	N/A	KSC	CASE	01/21/93	DISASSEMBLY SCRATCH ON AFT DOME PRIMARY SEAL SURFACE
54-014	SQUAWK	N/A	N/A	N/A	KSC	CASE	01/21/93	DISASSEMBLY SCRATCHES ON AFT DOME PRIMARY SEAL SURFACE
54-024	SQUAWK	N/A	N/A	N/A	KSC	CASE	01/26/93	INNER LIGAMENT CRACK ON THE AFT STIFFENER STUB
54-025	SQUAWK	N/A	N/A	N/A	KSC	CASE	01/26/93	PITTING AT FORWARD FIELD JOINT SPOT BOND LOCATIONS
54-026	SQUAWK	N/A	N/A	N/A	KSC	NOZZLE	01/26/93	BACKED OUT COMPLIANCE RING HELICAL COIL
54-027	SQUAWK	N/A	N/A	N/A	KSC	CASE	01/27/93	BLEND ON THE AFT FIELD JOINT INNER CLEVIS LEG ID
54C-02	PRELIM.	N/A	N/A	N/A	H-5/H-7	NOZZLE	02/02/93	ABNORMAL FIXED HOUSING METAL-TO-ADHESIVE BONDLINE FAILURE MODE
54C-03	PRELIM.	N/A	N/A	N/A	H-5/H-7	SEAL SURF.	11/11/11	HEAVY CORROSION ON NOZZLE THROAT HOUSING (JOINT 4) SEALING SURFACE
360L029A-01	PFAR	54-002	N/A	N/A	KSC	JPS/TPS	02/10/93	SPONGY AREA ON LH AFT FJPS
360L029B-02	PFAR	54-008	N/A	N/A	KSC	SEAL SURF.	02/10/93	SCRATCHES ON FIXED HOUSING RADIAL BOLT HOLE SPOTFACE SEALING SURFACE
360L029A-03	PFAR	54-011	N/A	N/A	KSC	SEALS	02/10/93	GRINDING MARKS ON NOZZLE-TO-CASE JOINT PACKINGS WITH RETAINERS
360L029B-04	PFAR	54-015	DR4-5/243	N/A	KSC	IGNITER	02/10/93	FOREIGN MATERIAL (HAIR) ON FORWARD DOME ADAPTER SEALING SURFACE
360L029B-05	PFAR	54-016	N/A	N/A	KSC	IGNITER	02/10/93	FOREIGN MATERIAL (WHITE SPECKS) ON IGNITER OUTER GASKET
360L029B-06	PFAR	54-017	N/A	N/A	KSC	IGNITER	02/10/93	FOREIGN MATERIAL (WHITE) ON IGNITER INNER GASKET
360L029B-07	PFAR	54-018	N/A	N/A	KSC	SEALS	02/10/93	SCALLOPED-SHAPED CLOSED FLOWLINES ON FIVE NOZZLE-TO-CASE JOINT PACKINGS WITH RETAINERS
360L029A-08	PFAR	54-019	N/A	N/A	KSC	IGNITER	02/10/93	FOREIGN MATERIAL (COLORED SPECKS) ON IGNITER OUTER GASKET
360L029A-09	PFAR	54-020	N/A	N/A	KSC	SEAL SURF.	02/10/93	SCRATCHES ON IGNITER ADAPTER SEAL SURFACE
360L029A-10	PFAR	54-021	N/A	N/A	KSC	IGNITER	02/10/93	FOREIGN MATERIAL (BLUE FIBERS AND YELLOW SPECKS) ON THE IGNITER INNER GASKET
360L029A-11	PFAR	54-022	N/A	N/A	KSC	INSULATION	02/10/93	DISCOLORED PUTTY ON INNER IGNITER JOINT
360L029B-12	PFAR	54-023	N/A	N/A	KSC	SEAL SURF.	02/10/93	SCRATCHES ON CENTER FIELD JOINT TANG PRIMARY AND SECONDARY SEAL SURFACES
360L029A-13	PFAR	54C-01	N/A	N/A	H-5/H-7	NOZZLE	02/10/93	ABNORMAL NOSE CAP METAL-TO-ADHESIVE BONDLINE FAILURE MODE

4.0 COMPONENT EVALUATIONS

The following sections detail, by component, the hardware condition observed at Clearfield.

4.1 Insulation

Internal insulation evaluations of the igniters, case acreage, joints, and liners are summarized in the following sections. PFORs documenting the observations are found in Appendix A. The Clearfield PEEP specified that the insulation on only the LH motor was to be evaluated. But, during motor operation a pressure spike occurred in the RH motor and it was requested by the customer that the RH motor insulation be evaluated for this flight set. Insulation Special Issues 1 through 5 were specific to the LH motor only and were completed as outlined in the Special Issues document–TWR 64219.

4.1.1 Thermal Performance Evaluation

Summaries of the safety factors for the nozzle-to-case joint, field joint, factory joint, case acreage and igniter adapter are found in Table III through Table VI, respectively. All safety factors for these areas can be found in Appendix E, Tables E–I through E–XIII. Note that all joint insulation regions, including factory joints, must meet a minimum safety factor of 2.0. A minimum safety factor of 1.5 is required in the acreage insulation regions.

All safety factors were within CEI specification limits. All thermal protection requirements were met.

4.1.2 Internal Insulation Samples

The Clearfield PEEP specified that removal of standard insulation samples was not required on RSRM–29. Aft dome samples were removed per the special issues, the density variation evaluation of these samples are discussed in 4.1.5.1.

Table III. Summary of RSRM-29, Nozzle-to-Case Joint and Field Joint Insulation Safety Factors

Joint	Min. Compliance Safety Factor (CSF) *	Degree Location	Min. Actual Safety Factor (ASF) *	Degree Location
Nozzle/Case Joint, RH	3.7	180.0	4.3	180.0
Aft Field Joint, RH	6.0	136.0	6.4	136.0
Center Field Joint, RH	12.2	2.0	13.0	2.0
Forward Field Joint, RH	10.8	180.0	11.7	180.0

* Minimum required joint insulation safety factor is 2.0.

Table IV. Summary of RSRM-29, Factory Joint Insulation Safety Factors

Joint	Station (inches)	Min. Compliance Safety Factor (CSF) *	Degree Location	Min. Actual Safety Factor (ASF) *	Degree Location
Aft Dome/ Stiffener, RH	56.0	3.18	270.0	3.90	270.0
Stiffener/ Stiffener, RH	177.7	2.27	226.8	3.43	226.8
Stiffener/ET Attach, RH	299.1	3.06	180.0	4.98	180.0
Aft Center, RH	163.0	2.34	270.0	5.45	270.0
Forward Center, RH	163.0	3.63	180.0	8.46	180.0
ForwardCylinder/ Cylinder, RH	162.0	3.80	154.0	5.22	154.0
Forward Dome/ Cylinder, RH	321.0	2.41	222.0	2.65	222.0

* Minimum required joint insulation safety factor is 2.0.

Table V. Summary of RSRM-29, Case Acreage Insulation Safety Factors

Segment	Min. Compliance Safety Factor (CSF) *	Station (inches)	Degree Location	Min. Actual Safety Factor (ASF) *	Station (inches)	Degree Location
Aft Dome, RH	2.14	17.3	0.0	2.42	17.3	0.0
Aft, RH	1.89	98.0	46.8	2.11	214.0	136.8
Aft Center, RH	1.52	30.7	316.0	2.93	71.5	270.0
Forward Ctr., RH	4.41	14.5	13.0	5.12	145.0	136.0
Forward, RH	1.97	397.0	222.0	2.45	397.0	222.0

* Minimum required case acreage insulation safety factor is 1.5.

Table VI. Summary of RSRM-29, Igniter Insulation Safety Factors

	Min. Compliance Safety Factor (CSF) *	Station	Degree Location	Min. Actual Safety Factor (ASF) *	Station	Degree Location
RH Adapter	2.76	11	330.0	3.29	11	330.0
LH Adapter	2.74	11	180.0	3.27	11	180.0
RH Outer Joint	4.36	403.0	74.0	4.92	403.0	74.0

* Minimum required safety factors are 1.5 for the chamber and adapter acreage and 2.0 for the igniter joints.

4.1.3 Liner

Detailed liner maps for the RH segments are included in Appendix A. The remaining liner patterns were typical of past flight motors.

4.1.4 Igniter Nozzle Insert

LH

The postflight igniter nozzle insert throat diameter measurements were 6.446 inches at 0 degrees, 6.409 inches at 60 degrees, and 6.462 inches at 120 degrees. Using the maximum postfire measurement provides a thermal factor of safety of 7.3.

RH

The postflight igniter nozzle insert throat diameter measurements were 6.362 inches at 0 degrees, 6.402 inches at 60 degrees, and 6.414 inches at 120 degrees. Using the maximum postfire measurement provides a thermal factor of safety of 8.2.

4.1.5 Results of Special Issues and Concerns (Insulation)

TWR-64219 identified areas for special evaluation for RSRM-29. The insulation issues and results are listed below.

1. Condition: Density variations were seen on the x-rays of the CF/EPDM used in the aft dome of the LH aft segment.

Reference: DR 410559.

Results: Density variations in the LH aft segment CF/EPDM:

Insulation samples were dissected from the aft domes of the RSRM-29A aft segment, where density variations had been seen in loaded level x-rays, and from the aft dome of RSRM-28B, which had shown normal x-rays. Samples were removed at 0, 120, and 240 degrees from each aft dome to provide representative samples throughout each dome.

No differences were identified in the samples during visual examination or through Real Time Radiology (RTR) taken by the Nondestructive Test Quality Engineering group. The samples from each motor showed a uniform appearance with no evidence of density variation.

An evaluation was also conducted to determine what effects the density variation had on Material Decomposition Depths (MDDs) of the material. The following table provides a comparison of the median MDDs demonstrated on the RSRM-29A and 29B aft domes, and the median, maximum median and minimum median for the last ten measured flight domes. This evaluation includes nine stations in the aft dome CF/EPDM region.

Station	RSRM-29A Median MDD	RSRM-29B Median MDD	Median MDD	Maximum Median MDD	Minimum Median MDD
10.7	1.104	1.146	1.105	1.516	0.820
12.0	1.113	1.148	1.036	1.351	0.843
13.1	1.052	1.125	1.019	1.481	0.783
14.4	0.977	1.337	0.988	1.474	0.712
16.0	0.915	1.491	0.882	1.435	0.657
17.3	0.825	1.449	0.769	1.411	0.601
18.5	0.627	1.238	0.687	1.322	0.476
19.5	0.600	0.971	0.602	1.054	0.439
21.3	0.647	0.739	0.543	1.018	0.436

Median, maximum median, and minimum median MDDs are based on flight motors RSRM-20A, 20B, 21A, 21B, 22B, 24A, 25B, 26A, 27B, and 28A

From this evaluation is is evident that the RSRM-29B Aft dome consistently showed higher median MDDs when compared to the RSRM-29A Aft dome with the density variations. The median MDDs for the RSRM-29A Aft dome were also very consistent with median MDDs for the last ten aft domes measured.

The density variations identified in the x-rays of the aft dome of the RSRM-29A aft segment do not appear to affect the performance of the insulation. The fact that the density variations were not identified on the RTR of the samples removed from the RSRM-29A aft dome is not completely understood.

Measurement of the aft segment NBR inhibitors:

No NBR inhibitor measurements were taken on the LH aft segment. Inhibitor measurements for the RH aft segment are documented on PFOR A-2 Page A-12a in Appendix A.

Measurement of the aft center segment NBR inhibitors:

The NBR inhibitor measurements taken on the LH aft center segment are documented on PFOR A-2 on page A-4. Inhibitor measurements for the RH aft center segment are documented on PFOR A-2 Page A-11 in Appendix A.

Measurement of the forward center segment NBR inhibitors:

No NBR inhibitor measurements were taken on the LH forward center segment. Inhibitor measurements for the RH forward center segment are documented on PFOR A-2 Page A-10 in Appendix A.

2. Condition: Questionable thermal performance on a test lot of CF/EPDM insulation was experienced on a 70-lb char motor test. Although subsequent testing has shown the production lot of material to have acceptable performance characteristics, there are still concerns about the CF/EPDM utilized under the stress relief flap in the LH forward center segment.

Reference: DR 411468-01.

Results: Evaluation of the CF/EPDM under the stress relief flap of the LH forward center segment showed CF/EPDM remaining with no unusual erosion identified.

3. Condition: During ultrasonic thickness inspection of the RSRM-38A aft segment NBR inhibitor, thin areas were detected. A Unexpected/Unintended Event or Condition (UUEC) Investigation team has been formed and has requested postfire aft segment NBR inhibitor thickness measurements.

Reference: DR 414634-01.

Results: Clearfield Refurbishment Center failed to do work on LH aft segment. Results of RH segment can be found on PFOR A-2 on Page A-12a of Appendix A.

4. Condition: During ultrasonic thickness inspection of the RSRM-38A aft segment NBR inhibitor, thin areas were detected. A UUEC Investigation team has been formed and has requested postfire aft center segment NBR inhibitor thickness measurements.

Reference: DR 414634-01.

Results: LH aft center segment thicknesses are found on PFOR A-2 Page A-4 Appendix A. RH aft center segment thicknesses are found on PFOR A-2 Page A-11 of Appendix A.

5. Condition: During ultrasonic thickness inspection of the RSRM-38A aft segment NBR inhibitor, thin areas were detected. An UUEC Investigation team has been formed and has requested postfire forward center segment NBR inhibitor thickness measurements.

Reference: DR 414634-01.

Results: LH forward center measurements were not taken. RH measurements are found on PFOR A-2 Page A-10 of Appendix A.

6. Condition: Per requirements of Configuration Control Board Directive (CCBD) SM3-01-4640. para. (g), the 1U minimum insulation thickness at the aft segment station 177.7 will be increased from 1.00 inch to 1.20 inches.

Reference: 1U77503, CCBD SM3-01-4640.

Results: The minimum prefire thickness measured at the 177.0 inch station of the RSRM-29B aft segment was 1.469 at 270 degrees. Calculation of the CSF at the location with the maximum MDD resulted in a minimum CSF of 2.73 (1.20/0.440 = 2.73). Use of the previous 1U drawing minimum showed a minimum CSF of 2.27.

7. Condition: A small deviation in the pressure trace was observed during the launch of RSRM-29B. A UUEC team was formed to investigate this pressure "blip".

Reference: AO 4C2-1126.

Results: Additional postflight inspection was performed on RSRM-29B segments.

4.2 Case, Seals, and Joints

Seal and Joint evaluations of the S&As, factory joints, internal nozzle joints, ports, and port plugs were performed. PFORs documenting the observations are found in Appendix B.

4.2.1 S&As

Figure 2 shows the S&A configuration. The S&As were disassembled on January 28, 1993, at the Clearfield H-5 facility. The following is a summary of the assessment observations.

No anomalous conditions were observed. No O-ring or other seal surface damage was observed. A small cluster of surface roughness was observed near the seal surface under the LH 18-degree SII.

4.2.2 Factory Joints

The factory joints were inspected by Quality Assurance at Clearfield. All fourteen factory joints were in good condition with no O-ring heat effect or erosion observed. The RH forward dome joint had small areas of heavy corrosion. The LH forward dome joint had minor fretting and small areas of medium corrosion. None of these conditions adversely affected the performance of the joint.

4.2.3 Internal Nozzle Joints

Details concerning the nozzle internal joint performance can be found in Section 4.3.

4.2.4 Port Plugs and Port Plug Seals

S&As
No anomalous conditions were observed. Circumferential lines were observed under the LH 126-degree leak test plug head (MS9902-01, ECL0011). These lines did not extend into the seal zone. No other O-ring, plug or seal surface damage was observed.

Factory Joints
No anomalous conditions were observed on any of the leak test ports, plugs or plug O-rings.

Internal Nozzle Joints
No anomalous conditions were observed on any of the leak test ports, plugs or plug O-rings.

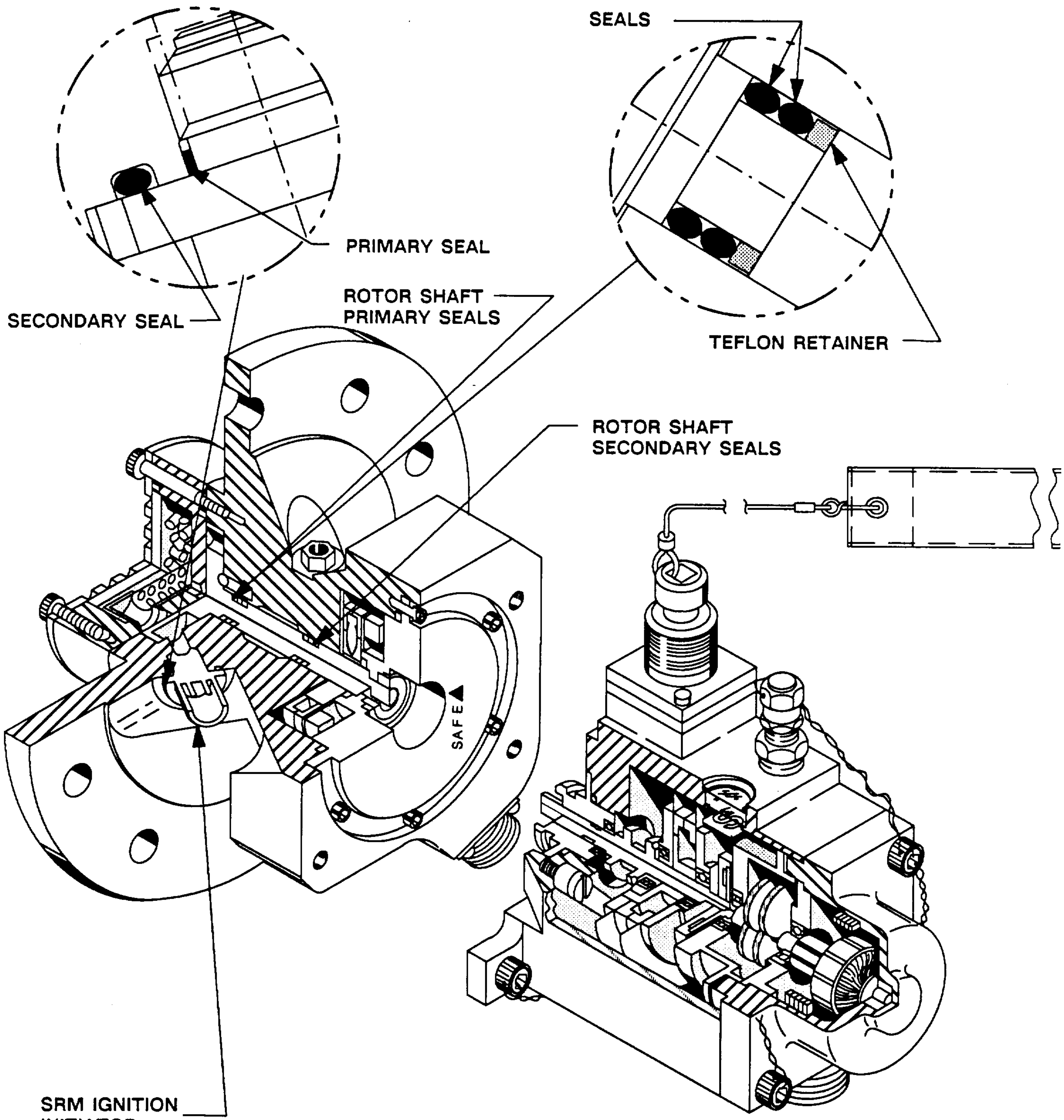

Figure 2. Safe and Arm Device Configuration

4.2.5 Results of Special Issues and Concerns (Case, Seals, and Joints)

TWR-64219 identified areas for special evaluation of RSRM-29, at Clearfield. The Case and Seals had no Special Issues identified but there was one Special Issue on one of the Joints.

1. Condition: Incorrect dash number pin retainer bands were installed over the RH forward dome factory joint. The pin retainer bands installed over the RH forward dome factory joint do not have primer which may cause an increase in corrosion in areas of weatherseal unbonds (bare metal). It is desirable to investigate the effects of missing primer on corrosion protection and on the bond system.

Reference: DR 413086-01.

Results: A detailed evaluation was not performed during disassembly. However, the normal postflight disassembly evaluation indicated no anomalous conditions (reference Section 4.2.2).

4.3 Nozzle

Figure 3 shows the RSRM-29 internal nozzle joint nomenclature and details the internal nozzle joint configuration used in this report. The nozzles were off-loaded at Clearfield H-6 on January 25, 1993.

The LH nozzle showed slight intermittent scrape marks on the OD of the fixed housing flange from 230-to-240 and 300-to-305 degrees. The RH nozzle also showed slight intermittent shipping scrapes on OD of fixed housing mounting flange from 240-to-305 degrees.

The internal nozzle joints were disassembled on January 27-28, 1993, at the H-6 facility in Clearfield. The condition of the RSRM-29 nozzle joints was generally typical of previous flight nozzles. RTV was below the char line in all joints. The primary and secondary O-rings in all joints showed no signs of blowby, erosion, heat effects or disassembly damage. There was no significant metal hardware damage.

The following sections provide detailed assessments of nozzle internal joints, bondlines, char and erosion performance, flex boot, bearing protector and flex bearing performance, and throat erosion data. The outcome of special issues and concerns for this nozzle flight set is also presented. PFORs documenting the observations are found in Appendix B and C.

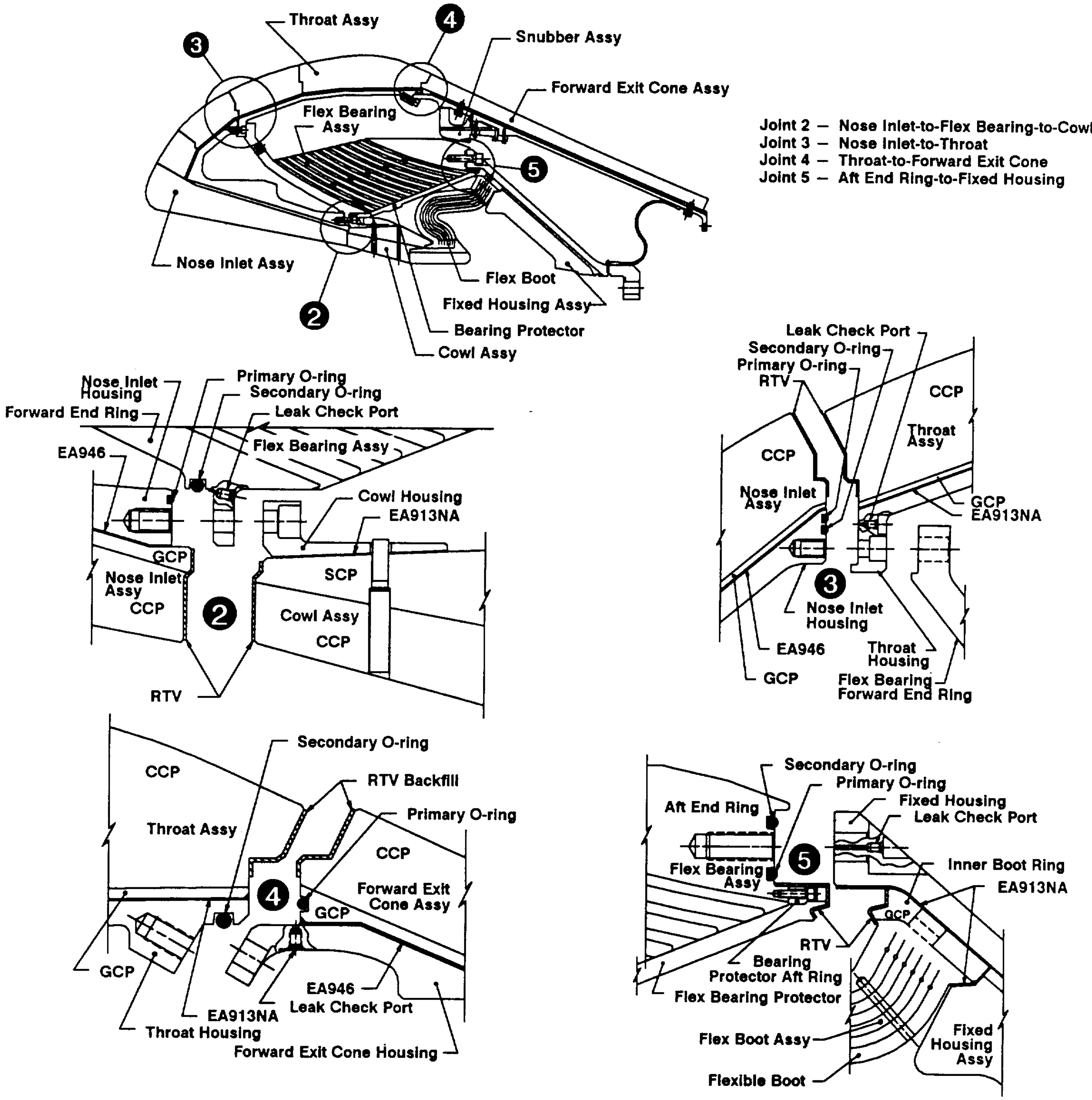

Figure 3. Internal Nozzle Joint Configuration

4.3.1 Nose Inlet/Forward End Ring/Cowl (Joint 2)

LH

Typical soot entered the joint between the layers of RTV and adhesive. Soot reached the primary O-ring intermittently around the full circumference. A terminated gas path in the RTV was observed at 310 degrees. The forward end ring flange OD had intermittent bubbled paint at 0-to-180 degrees. Missing paint on OD flange of forward end ring intermittent full circumference.

Typical scallop shaped sooting between bolt holes was observed full circumference. Soot reached the primary O-ring at 72-to-84, 90-to-93, 162-to-168 and 306-to-318 degrees. No seal surface, O-ring or leak test plug damage was observed. The leak test plug breakaway torque was 30 in-lb and the running torque was 2 in-lb.

Light corrosion on the ID of cowl housing full circumference. Typical light-to-medium corrosion was observed outboard of the primary O-ring full circumference. No other metal damage was observed.

Grease coverage on the joint metal surfaces was nominal. No excessive grease was found in the bolt holes.

No separations were observed on the nose inlet and cowl assemblies.

RH

There was typical mixing of RTV and adhesive with the RTV reaching below the char line over the complete circumference. Soot was found on the aft face of the nose inlet housing. A terminated gas path in the RTV was observed at 352 degrees. Typical scallop shaped sooting between bolt holes was observed full circumference. Soot reached the primary O-ring from 156-to-174 and 204-0-24 degrees. There was missing paint (chipped) on the forward end ring forward flange OD intermittently around the full circumference.

Intermittent light corrosion was located on the forward end chamfer area of the cowl housing. Light corrosion was also located on the ID of the cowl housing full circumference. Typical light-to-medium corrosion was observed outboard of the primary O-ring intermittently full circumference on both the nose and forward end ring.

Grease coverage on the joint metal surfaces was nominal. No excessive grease was found in the bolt holes. Typical burnishing was observed intermittently on the nose inlet secondary O-ring seal surface. Other than the typical burnish marks, no seal surface, O-ring or leak test plug damage was observed. The leak test plug breakaway torque was 50 in-lb and the running torque was 25 in-lb.

No separations were observed on the nose inlet and cowl assembly.

4.3.2 Nose Inlet/Throat (Joint 3)

LH

No anomalous conditions were observed. A separation within the CCP was observed on the nose inlet assembly at 15–to–82 degrees with a maximum radial width of 0.030 inch. A metal–to–adhesive separation was observed on throat assembly at 130–to–161 and 190–to–200 degrees with a maximum radial width of 0.015 inch. RTV was below the char line over complete circumference. No gas paths were observed in this joint.

Light–to–medium corrosion at metal–to–adhesive interface full circumference on both throat and nose assemblies. Light–to–medium corrosion was also observed around the circumference inboard of the primary O–ring groove on both the nose inlet and throat housings. No other metal damage was observed.

Grease coverage on the joint metal surfaces was nominal. No excessive grease was found in the bolt holes.

No O–ring, seal surface, or leak check port plug damage was observed. The leak check port plug breakaway torque was 37 in–lb and the running torque was 18 in–lb.

RH

No anomalous conditions or corrosion were observed. Two metal–to–adhesive separations were present on the nose inlet assembly at 30–to–38 and 130–to–140 degrees with a maximum radial width of 0.005 inch. A separation within the CCP was observed on the throat assembly at 290–to–300 degrees with a maximum radial width of 0.10 inch. A metal–to–adhesive separation was observed on the throat assembly around the full circumference with a maximum radial width of 0.005 inch.

The RTV reached below the char line over the complete circumference. Grease did not interfere with the RTV fill in the joint. No gas paths were found in the joint.

No metal damage was observed.

Grease coverage on the joint metal surfaces was nominal. No excessive grease was found in the bolt holes.

No O–ring, seal surface, or leak check port plug damage was observed. The leak check port plug breakaway torque was 47 in–lb and the running torque was 20 in–lb.

4.3.3 Throat/Forward Exit Cone (Joint 4)

LH

The RTV reached below the char line over the complete circumference of the joint with no gas paths. RTV reached the primary O-ring at 0-to-35, 112-to-142, 150-to-255 and 310-to-335 degrees. Grease did not interfere with the RTV fill in the joint.

A metal-to-adhesive separation was present on the forward exit cone assembly at 35-to-55 degrees with a maximum radial width of 0.005 inch. Three adhesive-to-GCP separations were observed on the forward exit cone assembly at 82-to-105 and 158-to-185 with a maximum radial width of 0.020 inch and at 265-to-285 degrees with a maximum radial width of 0.015 inch. No separation was observed on the throat assembly.

Medium-to-heavy corrosion was observed on the throat housing primary O-ring sealing surface and chamfer intermittently full circumference. Preliminary PFAR 54C-03 was written reporting the heavy corrosion. Light-to-medium corrosion was also observed on the forward exit cone housing seal region intermittently from 200-to-290 degrees. No other metal damage was observed.

Grease coverage on the joint metal surface was nominal. There was no excess grease in the bolt holes of the throat support housing.

No O-ring, seal surface, or leak check port plug damage was observed. The leak check port plug breakaway torque was 43 in-lb and the running torque was 10 in-lb.

RH

No anomalous conditions were observed. The RTV reached below the char line over the complete circumference of the joint. No gas paths were present in the RTV. RTV reached the primary O-ring at 55-to-120 and 252.5-to-345 degrees. Grease did not interfere with the RTV back-fill in the joint.

Two metal-to-adhesive separations were observed on the forward exit cone assembly at 30-to-35 and 50-to-55 degrees with a maximum radial width of 0.005 inch. A single GCP-to-CCP separation was observed on the forward exit cone assembly at 332-0-32 degrees with a maximum radial width of 0.045 inch. A metal-to-adhesive separation was observed on the throat assembly around the full circumference with a maximum radial width of 0.013 inch.

Medium–to–heavy corrosion was observed on the aft end of the throat between the primary and secondary seal from 180–to–205 degrees and 85–to–140 degrees. Intermittent light–to–medium corrosion was observed on the secondary sealing surface on the forward exit cone housing at 97–to–107 degrees. Light–to–medium corrosion was observed on the leak check port spotface. No other metal damage was observed.

Grease coverage on the joint metal surface was nominal. There was no excess grease in the bolt holes.

No O–ring, seal surface, or leak check port plug damage was observed. The leak check port plug breakaway torque was 37 in–lb and the running torque was 12 in–lb.

4.3.4 Flex Bearing/Fixed Housing (Joint 5)

LH

No abnormal conditions were observed. The RTV coverage was nominal with intermittent encapsulated voids due to the assembly process. RTV reached primary O–ring at 50–to–107, 225–to–230 and 240–to–245 degrees.

Intermittent light–to–medium corrosion was observed on the aft end ring flange ID full circumference. Medium corrosion was also observed on port spotface. Twenty–nine Packing with Retainers were observed to have light–to–medium corrosion on OD. No other metal damage was observed.

All 72 Packing with Retainers had typical disassembly damage to the elastomer. No metal damage or rounded chamfers were observed on the spotface of the fixed housing bolt through holes. No O–ring, seal surface, or leak check port plug damage was observed The leak check port plug breakaway torque was 35 in–lb and the running torque was 8 in–lb.

Grease coverage on the joint metal surfaces was nominal with no excess grease in the bolt holes.

No separations were observed between the inner boot ring and the fixed housing.

RH

No abnormal conditions were observed. The RTV coverage was nominal. The RTV extended to the primary O–ring at 40–to–70, 130 and 220–to–250 degrees. Typical intermittent voids were observed in the RTV due to the assembly process. The largest void measured 0.5 inch radial by 14.3 inches circumferential. No gas paths were present in the RTV.

Medium corrosion was observed on the aft end ring flange ID intermittently from 150–0–80 degrees. Light corrosion was observed on the aft end ring and fixed housing between O-ring grooves intermittent full circumference. Intermittent light corrosion was observed on the fixed housing forward flange ID full circumference. Water was observed on the joint metal surfaces. Light corrosion was observed on the Packing with Retainer spotfaces on the fixed housing at the following degree locations: 130, 155, 160, 165, 170, 215 and 245. One Packing with Retainer was observed to have light corrosion on its face. No other metal damage was observed.

Sixty–five of the 72 Packings with Retainers had typical disassembly damage to the elastomer. No metal damage or rounded chamfers were observed on the spotfaces. No O–ring, seal surface, or leak check port plug damage was observed. The leak check port plug breakaway torque was 44 in–lb and the running torque was 23 in–lb.

Grease coverage on the joint metal surfaces was nominal.

No separations were observed between the inner boot ring and the fixed housing.

4.3.5 Aft Exit Cone Assembly Bondlines

LH

The primary mode of separation was 100 percent within the GCP. The secondary mode of separation was 100 percent adhesive–to–GCP. No adhesive voids had a diameter greater than 0.5 inch. Intermittent small voids (0.05–to–0.10 inch diameter maximum) were seen throughout the polysulfide.

RH

The primary mode of separation was 71 percent within GCP, 18 percent metal–to–adhesive and 11 percent adhesive–to–GCP. The secondary mode was 100 percent adhesive–to–GCP. One adhesive void had a diameter greater than 0.5 inch. Intermittent small voids (0.10 inch diameter maximum) were seen throughout the polysulfide. No voids extended the full axial length of the groove. The polysulfide did not fill the bottom of the groove for a length of 90 degrees.

Medium corrosion was observed in the areas of adhesive–to–metal separation.

4.3.6 Forward Exit Cone Assembly Bondlines

LH

Mode of separation was 76 percent adhesive–to–GCP, 14 percent metal–to–adhesive and 10 percent within adhesive. The CCP was removed prior to bondline assessment to complete shear pin assessment. Four adhesive voids had a diameter greater than 0.5 inch.

Medium–to–heavy corrosion on areas of the adhesive–to–metal separation.

RH

Mode of separation was 65 percent adhesive–to–GCP, 25 percent metal–to–adhesive and 10 percent average within the adhesive. The CCP was removed prior to bondline assessment to complete shear pin assessment. One adhesive void had a diameter greater than 0.5 inch.

Medium–to–heavy corrosion on areas of the adhesive–to–metal separation.

4.3.7 Throat Assembly Bondlines

LH

The throat inlet ring and throat ring mode of separation was 100 percent metal–to–adhesive. Four adhesive voids had a diameter greater than 0.5 inch.

Medium–to–heavy corrosion full axial length of throat support housing and full circumference.

RH

The throat inlet ring and throat ring mode of separation was 94 percent metal–to–adhesive, 5 percent adhesive–to–GCP and 1 percent within GCP. Several adhesive voids had a diameter greater than 0.5 inch.

Medium–to–heavy corrosion was present the full axial length of the throat support housing and full circumference.

4.3.8 Nose Inlet Rings Bondlines

LH

The mode of separation was 91 percent metal–to–adhesive, 8 percent adhesive–to–GCP and 1 percent within the adhesive. One adhesive void had a diameter greater than 0.5 inch.

Medium corrosion on areas at the adhesive–to–metal separation.

RH

The mode of separation was 95 percent metal–to–adhesive and 5 percent average adhesive–to–GCP. One adhesive void had a diameter greater than 0.5 inch.

Medium corrosion was present at 340 degrees.

4.3.9 Nose Cap Bondlines

LH

The primary mode of separation was 97 percent GCP–to–CCP, 2 percent metal–to–adhesive and 1 percent within GCP. The secondary mode of separation was 71 percent average adhesive–to–GCP and 29 percent metal–to–adhesive. The bulk of metal–to–adhesive separations occurred on the forward 1–to–2 inches and aft 3–to–4 inches. No adhesive voids had a diameter greater than 0.5 inch.

The total nose cap metal–to–adhesive separation was 30 percent. The nominal condition is 30 percent and occurs on the forward and aft end of the bondline. There was a greater amount of metal–to–adhesive separation in the center of the bondline, 7.0–to–9.0 inches from the aft end. The largest area was located at 50–to–140 degrees with a maximum width of 5.0 inches axial. No corrosion was observed in the center area of metal–to–adhesive separation. PFAR 360L029A–13 was written reporting this condition.

Medium corrosion was observed on forward 1–to–2 inches and aft 3–to–4 inches around the full circumference on the nose inlet housing.

RH

The mode of separation was 100 percent GCP–to–CCP. The secondary mode of separation was 80 percent adhesive–to–GCP and 20 percent metal–to–adhesive. One adhesive void had a diameter greater than 0.5 inch.

Light corrosion was observed on forward 1–to–2 inches and aft 3–to–4 inches around the full circumference on the nose inlet housing.

4.3.10 Cowl Bondlines

LH

The mode of separation was 99 percent metal–to–adhesive and 1 percent adhesive–to–SCP (around pin holes). Seven adhesive voids had a diameter greater than 0.5 inch. Intermittent intermixed adhesive and RTV was present on the forward 0.5 inch.

Light–to–medium corrosion was observed on the bonding surface around the full circumference.

RH

The mode of separation was 100 percent metal–to–adhesive. Seven adhesive voids had a diameter greater than 0.5 inch.

Light–to–medium corrosion was observed on the bonding surface around the full circumference.

4.3.11 Fixed Housing Assembly Bondlines

LH

The mode of separation was 80 percent metal–to–adhesive and 20 percent GCP–to–CCP. A preliminary PFAR 54C–02 was written because the metal–to–adhesive separation exceeded 15 percent. The secondary mode of separation was 100 percent adhesive–to–GCP. Ten adhesive voids had a diameter greater than 0.5 inch.

No corrosion was observed on the housing.

Ultrasonic inspection did detect unbonds and are detailed in section 4.3.12. Stains were observed on the housing marking the location of the unbonds. Hardness checks were performed on the housing and indicated no sign of heat affects.

RH

The primary mode of separation was 72 percent within GCP, 18 percent GCP–to–CCP and 10 percent metal–to–adhesive. The secondary mode of separation was 100 percent adhesive–to–GCP. Five adhesive voids had a diameter greater than 0.5 inch.

No corrosion was observed on the housing.

Ultrasonic inspection did detect unbonds and are detailed in section 4.3.12. Stains were observed on the adhesive and housing marking the location of the unbonds. Hardness checks were performed on the housing and no indications of heat effects were found.

4.3.12 Ultrasonic Inspection of Fixed Housing Assemblies

Ultrasonic inspection was conducted on both of the fixed housing assemblies. Four small indications were found on the left fixed housing and one small indication was found on the right fixed housing.

4.3.13 Char and Erosion Performance

Char and erosion margins of safety are summarized in Table VIII. The char and erosion data tables for each Nozzle component liner can be found in Tables D–I through D–XIV in Appendix D. Measurement stations that contain an "N/A" means that data was not available due to missing material. The aft exit cone liners were not recovered and therefore are not included. All stations showed positive margins of safety. The measurement stations can be found in Figure D–1 of Appendix D.

4.3.14 Flex Boot Performance

The performance of both flex boots was nominal. The LH hand flex boot had a minimum of 3.3 NBR plies intact and the RH flex boot had a minimum of 3.3 NBR plies intact. Positive margins of safety were achieved at all measurement stations. The flex boot performance margins of safety are summarized in Table IX. Typical even sooting on both flexible boot inside diameters was present.

Table VIII. RSRM-29 Nozzle Char and Erosion Minimum Margins of Safety

Hardware	Stations*												
Forward Exit Cone Assembly, LH	**1**	**4**	**4.6**	**8**	**12**	**16**	**20**	**24**	**28**	**32**	**32.9**	**34**	
	0.29	0.21	0.19	0.24	N/A	N/A	N/A	N/A	0.21	0.34	0.37	0.45	
Forward Exit Cone Assembly, RH	**1**	**4**	**4.6**	**8**	**12**	**16**	**20**	**24**	**28**	**32**	**32.9**	**34**	
	0.32	0.32	0.28	0.29	N/A	N/A	N/A	N/A	N/A	0.37	0.39	0.39	
Throat Assembly, LH	**1**	**2**	**4**	**6**	**8**	**10**	**12**	**14**	**16**	**18**	**20**	**22**	**23**
	0.16	0.15	0.14	0.08	0.03	0.13	0.20	0.25	0.32	0.39	0.50	0.40	0.26
Throat Assembly, RH	**1**	**2**	**4**	**6**	**8**	**10**	**12**	**14**	**16**	**18**	**20**	**22**	**23**
	0.14	0.14	0.14	0.09	0.07	0.15	0.21	0.26	0.33	0.38	0.41	0.44	0.27
Nose Inlet Rings (-503, -504), LH	**28**	**30**	**32**	**34**	**36**	**38**	**39**						
	0.19	0.27	0.15	0.40	0.32	0.18	0.11						
Nose Inlet Rings (-503, -504), RH	**28**	**30**	**32**	**34**	**36**	**38**	**39**						
	0.18	0.27	0.13	0.31	0.29	0.17	0.14						
Nose Cap, LH	**1.5**	**4**	**6**	**8**	**10**	**12**	**14**	**16**	**18**	**20**	**22**	**24**	**26**
	N/A	0.54	0.62	0.64	0.76	0.69	0.73	0.66	0.46	0.37	0.12	0.04	0.16
Nose Cap, RH	**1.5**	**4**	**6**	**8**	**10**	**12**	**14**	**16**	**18**	**20**	**22**	**24**	**26**
	N/A	0.58	0.62	0.73	0.73	0.	0.71	0.73	0.55	0.49	0.19	0.09	0.17
Cowl/OBR, LH	**0.3**	**1**	**2**	**3**	**4**	**5**	**6**	**6.8**	**8**	**9**	**10**	**11.3**	
	0.20	0.15	0.13	0.09	0.19	0.21	0.34	0.43	0.26	0.41	0.32	0.23	
Cowl/OBR, RH	**0.3**	**1**	**2**	**3**	**4**	**5**	**6**	**6.8**	**8**	**9**	**10**	**11.3**	
	0.31	0.26	0.25	0.23	0.30	0.32	N/A	N/A	N/A	0.46	0.40	0.33	
Fixed Housing Assembly, LH	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10.75**		
	1.41	0.78	0.72	0.77	0.69	0.83	0.91	1.08	1.21	1.36	0.47		
Fixed Housing Assembly, RH	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10.75**		
	1.74	0.83	0.90	0.90	0.93	0.89	0.89	1.02	1.13	1.76	0.63		
Aft Exit Cone, LH	**73.77**	**77.77**	**83.77**	**89.77**	**95.77**	**101.77**	**107.77**	**113.77**	**118.77**				
	1.41	0.78	0.72	0.77	0.69	0.83	0.91	1.8	1.21				
Aft Exit Cone, RH	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**				
	1.74	0.83	0.90	0.90	0.93	0.89	0.89	1.02	1.13				

* Station locations are shown in bold with the margin of safety shown below.

4.3.15 Bearing Protector Performance

Close examination showed both of the bearing protectors performed as expected during flight. Both of the protectors were evenly sooted around the circumference and showed typically greater erosion in line with the cowl vent holes. There was no evidence of heat effect on the flex bearing side of either bearing protector. PFOR C-9 in Appendix C shows the postflight bearing protector thickness measurements every 10 degrees.

Erosion was observed on the LH bearing protector aft of the belly band at 50 degrees. A corresponding area was observed on the flex boot in the same locations. It Appears that slag was trapped between the boot and bearing protector. Slag was found in the boot cavity.

Table IX. RSRM-29 Flex Boot Margins of Safety

	Left Hand			Right Hand		
Degree Location	Remaining Plies	Max. Material Affected Depth (in.)	Performance Margin of Safety	Remaining Plies	Max. Material Affected Depth (in.)	Performance Margin of Safety
0	3.7	1.17	0.42	3.4	1.27	0.31
90	3.3	1.30	0.28	3.9	1.11	0.50
180	3.9	1.11	0.50	4.0	1.08	0.55
270	3.4	1.27	0.31	3.3	1.30	0.28

* Minimum flex boot overall prefire thickness is 2.5 inches.

4.3.16 Cowl Insulation Segments

Both nozzles performed as expected during flight. No abnormal heat effects were observed and no soot was found at the cowl housing interface.

The mode of separation from the cowl housing LH segments was 48 percent metal-to-adhesive, 42 percent adhesive-to-segment and 10 percent within the segments. The RH segment mode of separation was 46 percent adhesive-to-segment, 35 percent metal-to-adhesive and 19 percent within the segments.

4.3.17 Flex Bearing Performance

LH

The flex bearing performance during flight was acceptable. There were no anomalies associated with flight or splashdown. Examination of the flex bearing revealed no damage, soot, heat effect, or flow indications.

RH

The flex bearing performance during flight was acceptable, with no anomalies reported. Examination of the flex bearing revealed no damage, soot, heat effect, or flow indications.

4.3.18 Throat Diameter

The average LH nozzle postfire throat diameter was 55.979 inches (erosion rate of 8.63 mils/sec based on an action time of 122.7 sec). The average RH nozzle postfire throat diameter was 55.980 inches (erosion rate of 8.65 mils/sec based on an action time of 122.6 sec). RSRM postfire throat diameters have ranged from 55.787 to 56.072 inches.

4.3.19 Results of Special Issues and Concerns (Nozzle)

TWR-64219 identified areas for special evaluation of RSRM-29, at Clearfield. The nozzle issues are listed below with their respective results.

1. Condition: During dryfit, an interference fit was found between the RH flex boot rubber and bearing protector. Repair was accomplished by machining material from the high spots of the ID of the boot in the area of interference.

Reference: DR 411350-01.

Results: No abnormal erosion or any other conditions were observed on the flex boot ID or bearing protector OD around the full circumference.

2. Condition: Low density indications (LDIs) are present in the RH cowl-to-nose cap interface (Joint 2). LDIs are located at:

Degree Location	Radial Depth (in.)	Axial Width (in.)	Circ Length (in.)
12	0.014	0.720	0.336
247	0.013	1.445	0.312
159	0.027	1.180	0.189
182	0.022	1.200	0.674
265	0.035	0.770	0.843

Reference: DR 410532-03.

Results: No indications of the LDIs were observed in the RTV on the RH Joint 2.

3. Condition: An LDI is present at the LH nose cap-to-forward nose ring interface. The LDI is located at 38 degrees and measures 1.00 inch axially by 0.20 inch radially by 0.50 inch circumferentially.

Reference: DR 407599-01.

Results: No indications of the LDIs were observed on the LH nose cap-to-forward nose ring interface.

4. Condition: Four LDIs are present at the RH nose cap–to–forward nose ring interface. These are located at:

Degree Location	Radial Depth (in.)	Axial Width (in.)	Circ Length (in.)
339	0.03	0.80	0.33
87	0.23	0.31	1.29
191	0.03	0.37	1.70
177	0.04	0.98	1.00

Reference: DR 407543–02.

Results: Adhesive voids were observed at 90, 191, and 335 degrees on the RH nose cap–to–forward nose ring that correlate closely with the LDIs. No indications were observed at 177 degrees.

5. Condition: High density indications (HDIs) are present at the RH nose cap–to–forward nose ring interface. The indications may be caused by shims in the bondline. The HDIs are located at:

Degree Location	Radial Depth (in.)	Axial Width (in.)	Circ Length (in.)
121	0.02	1.01	0.43
210	0.02	1.02	0.42

1.55 and 1.48 inches respectively, from the flow surface.

Reference: DR 410532–01.

Results: No indications were observed at 121 and 210 degrees on the RH nose cap–to–forward nose ring. Both HDI locations fall within the erosion and char region and most likely were consumed during motor operation.

6. Condition: An LDI is present at the LH forward nose ring bondline. The LDI is located at 80 degrees, and is 0.97 inch long by 0.44 inch circumferentially by 0.60 inch in the "F" direction along interface.

Reference: DR 407599–02.

Results: An adhesive void was observed at 78 degrees on the LH forward nose ring bondline that correlate closely with the LDI.

7. Condition: Two LDIs are present at the RH forward nose ring bondline at the following locations:

Degree Location	Radial Depth(in.)	Axial Width (in.)	Circ Length (in.)
296	0.070	0.510	0.17
144	0.080	0.290	0.22

Reference: DR 407593-01.

Results: An adhesive void was observed at 144 degrees on the RH forward nose ring bondline that correlate closely with the LDI. No indications were observed at 296 degrees.

8. Condition: Two LDIs are present at the RH cowl bondline. The LDIs are located at:

Degree Location	Radial Depth(in.)	Axial Width (in.)	Circ Length (in.)
7	0.02	0.30	0.34
9	0.03	0.68	0.42

Reference: DR 410532-02.

Results: Pit repair areas were observed at 8 and 10 degrees on the RH cowl housing bonding surface that correlate closely with the LDIs.

9. Condition: Two LDIs are present in the RH cowl SCP-to-CCP interface. The LDIs are located at:

Degree Location	Radial Depth(in.)	Axial Width (in.)	Circ Length (in.)
114 to 162	0.060	0.12	43.06
225 to 246	0.056	0.14	20.75

and are 2.3 and 3.05 inches respectively, aft of forward end.

Reference: DR 404244-01.

Results: Phenolic samples were lost during processing and LDIs could not be evaluated.

10. Condition: The LH flex boot has four gouges on the OD at 305 and 310 degrees. Gouges are at the interface between the fixed housing and boot assembly. Gouges are located at:

Defect Number	Radial Depth(in.)	Axial Width (in.)	Circ Length (in.)
1	0.075	0.100	1.250
2	0.075	0.100	1.250
3	0.075	0.100	0.700
4	0.075	0.100	0.700

Reference: DR 411358-01.

Results: No abnormal erosion patterns or propagation of the LDIs was observed.

11. Condition: The nozzle work center is gathering data relating to the correlation of voids with LDIs. This information is requested for cowl, nose cap, and forward nose ring bondlines.

Reference: Nozzle Work Center.

Results: Six voids were documented on the LH forward nose ring bondline. Two voids were documented on the LH nose cap bondline. Twenty-four voids were documented on the RH cowl bondline.

Four voids were documented on the RH forward nose ring bondline. Thirty voids and five pit repair areas were documented on the RH cowl bondline.